

# Half-Hohlraum Planar X-ray Drive Platforms on the National Ignition Facility

## Half-Hohlraum Conditions

### Half-hohlraum NIF platforms

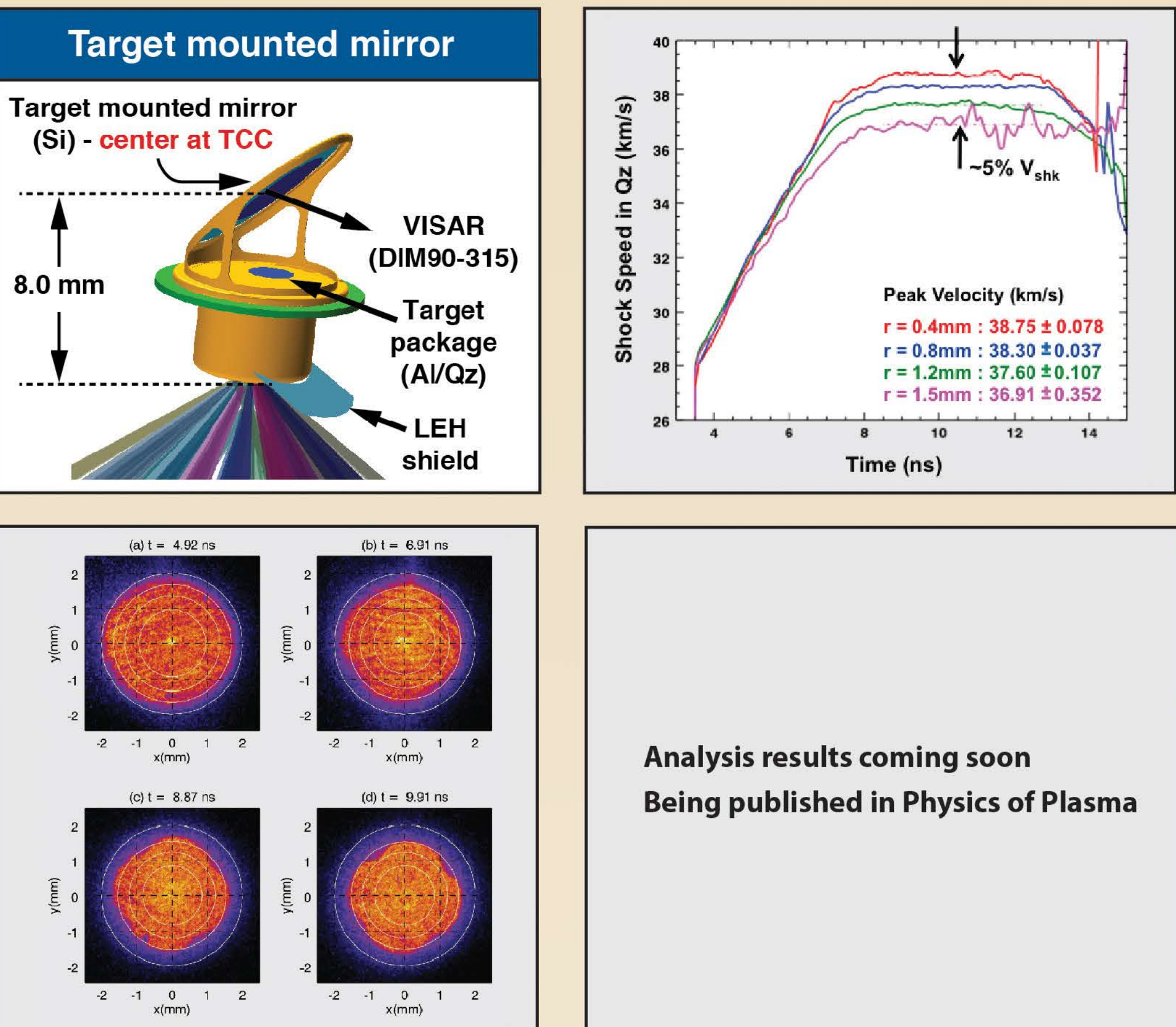
Planar Drive platforms are used to study shock and radiation flow physics

Platform	Subsonic radiation transport	Supersonic radiation flow	Ablative Rayleigh-Taylor growth	Shock/re-shock physics
Material	Ta <sub>2</sub> O <sub>5</sub>	C <sub>6</sub> H <sub>6</sub> Cl/SiO <sub>2</sub>	CH-I	CH
Density (g/cc)	0.5	0.1	1.0	0.06
Hohlraum peak temperature (eV)	240	350	170	250
Shock velocity (km/s)	~50	~500	~18	~140
Heam front velocity (km/s)	~18	~750	—	—
Laser energy (kJ)	350	370	270	400
Pulse duration (ns)	12	2.5	20	10
Pulse shape				

NIF makes it possible to perform experiments over a wide range of densities and temperatures

### X-ray Drive Planarity

Half-hohlraum platforms generate a uniform x-ray drive



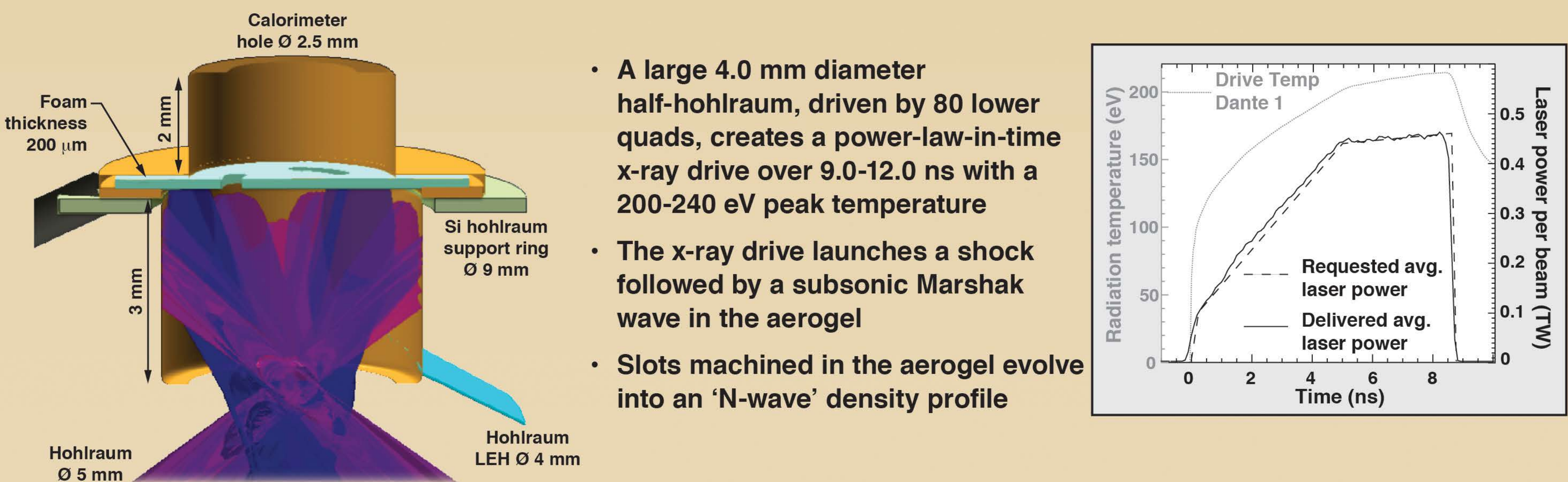
- X-ray drive planarity was characterized using VISAR; Uniformity and angular distribution of the emission were characterized using soft x-ray imaging and absolute flux measurements (DANTE) from multiple angles
- VISAR measurements across the diameter of the Radiation Transport half-hohlraum show approximately 5% drive pressure variation out to a radius of 1.5 mm
- Time-gated soft x-ray (900 eV) images of the laser entrance hole (LEH) are used to correct the hohlraum temperature and show 10-15% variation in emission from inside the half-hohlraum
- Measurements of the absolute flux emitted by the LEH of the 350 eV half-hohlraum at 37° and 64° are not well-fit by assuming a Lambertian source, but are in good agreement with post-shot simulations

Analysis results coming soon  
Being published in *Physics of Plasmas*

## Radiation Transport Platform

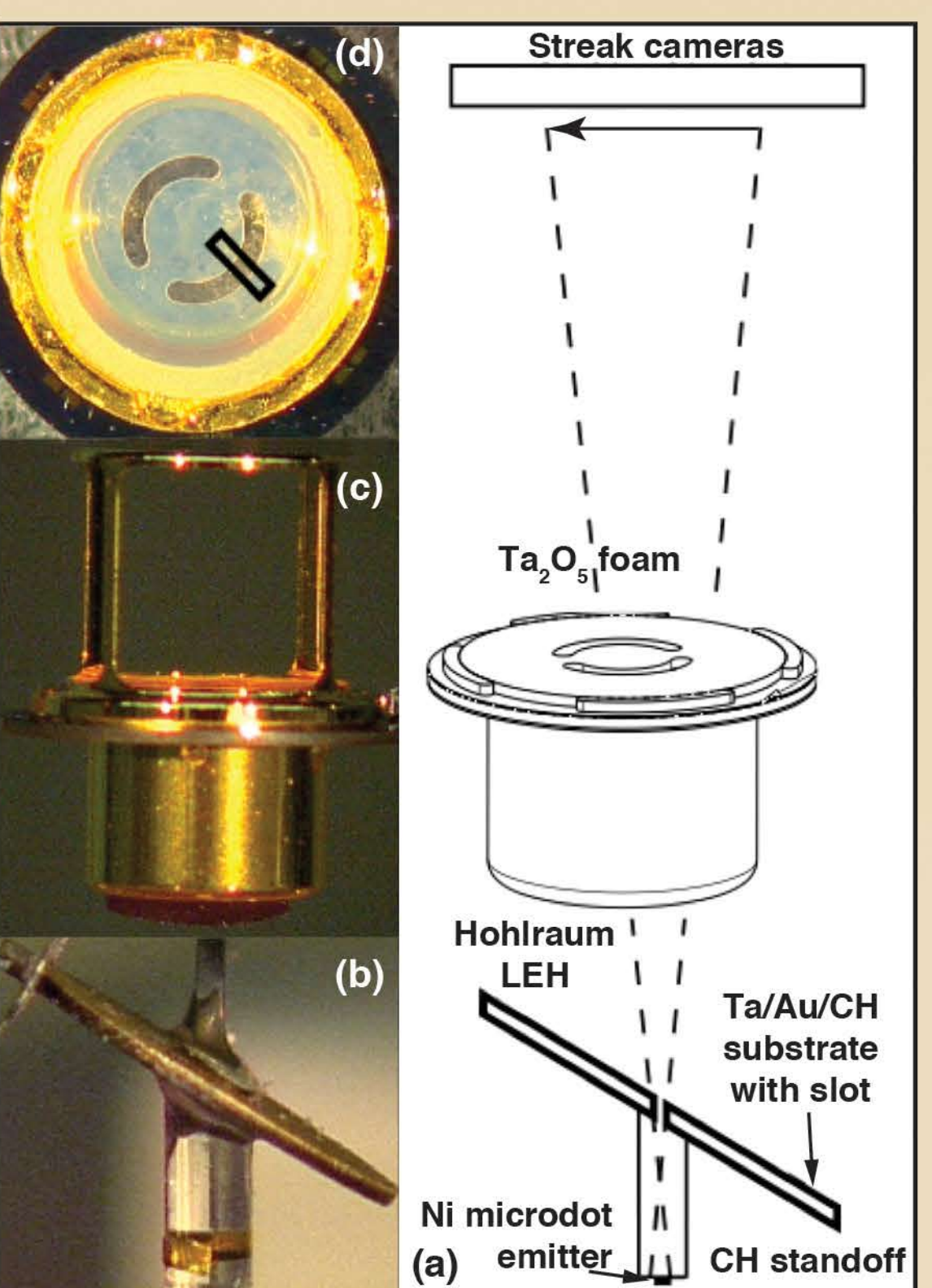
### Subsonic Radiation Transport

Subsonic Radiation Transport experiments study the evolution of an "N-wave" density structure in slots cut into a Ta<sub>2</sub>O<sub>5</sub> aerogel



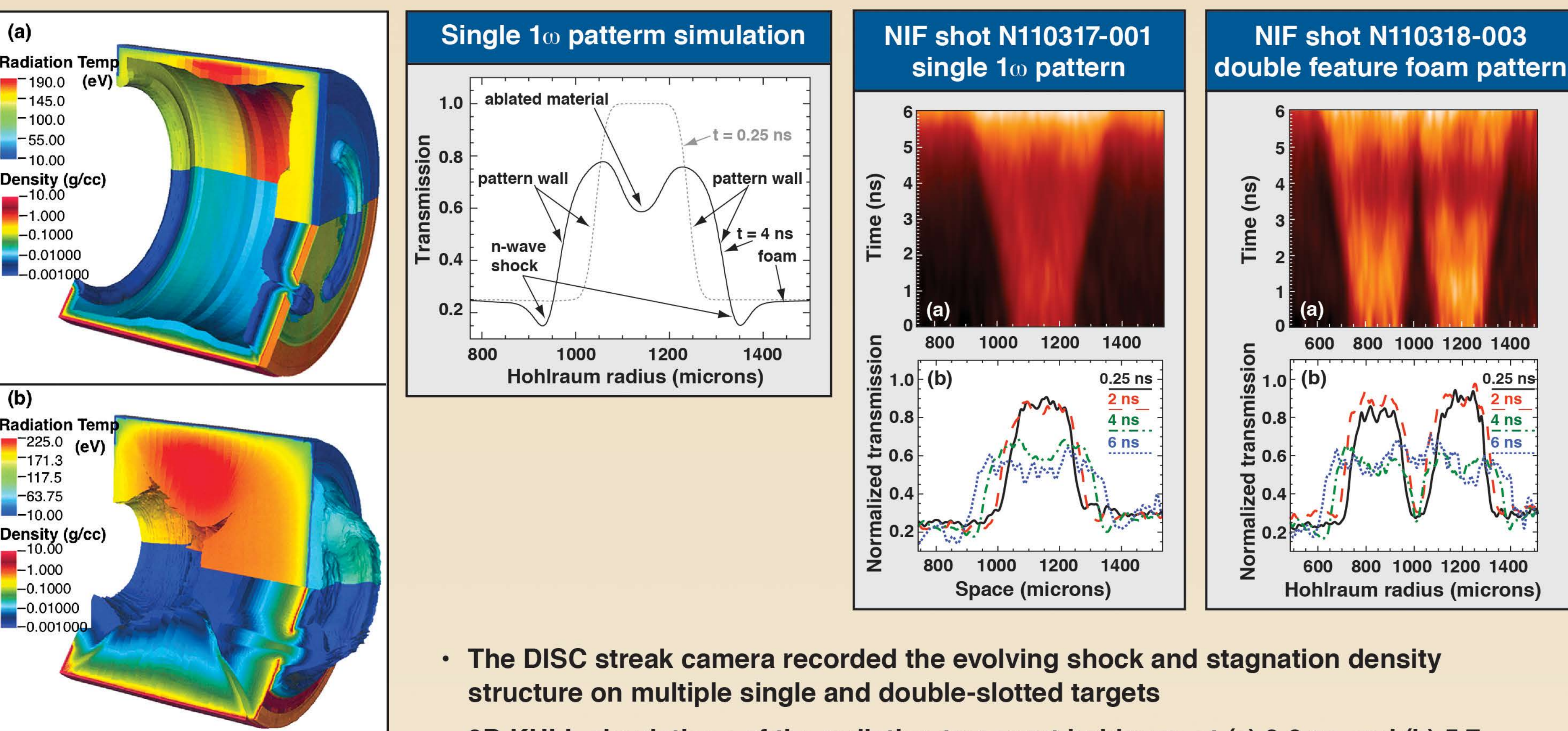
- A large 4.0 mm diameter half-hohlraum, driven by 80 lower quads, creates a power-law-in-time x-ray drive over 9.0-12.0 ns with a 200-240 eV peak temperature
- The x-ray drive launches a shock followed by a subsonic Marshak wave in the aerogel
- Slots machined in the aerogel evolve into an 'N-wave' density profile

Ni He- $\alpha$  (7.8 keV) point-projection on-axis radiography in DIM 0-0 is used to measure the slot-density profile



- A backlighter was positioned 31.2 mm below the hohlraum LEH. This incorporated a 2.0 mm CH spacer to support the BL microdot and prevent shock-loading and closure of the 30 x 200  $\mu$ m Ta pinhole
- The Ni microdot was illuminated by 16 kJ from 8 beams at an average intensity of  $4 \times 10^{14}$  Wcm<sup>-2</sup> for 8 ns
- The Ta pinhole substrate was tilted at 30° to prevent spall from damaging the streak camera. Spatial resolution of 20  $\mu$ m was demonstrated
- Data was recorded on a 20 ns sweep on the streak camera, filtered by 25  $\mu$ m Ni and 350  $\mu$ m Kapton and with a temporal resolution of 310 ps

High-quality streaked radiographs of the evolving density structure agree well with 3D KULL simulations



- The DISC streak camera recorded the evolving shock and stagnation density structure on multiple single and double-slotted targets
- 3D KULL simulations of the radiation transport hohlraum at (a) 2.0 ns and (b) 5.7 ns show how material has begun to fill the hohlraum, but not stagnate by 5.7 ns
- Streaked radiography simulations are in good agreement with the overall shape and slot width present in the measured transmission

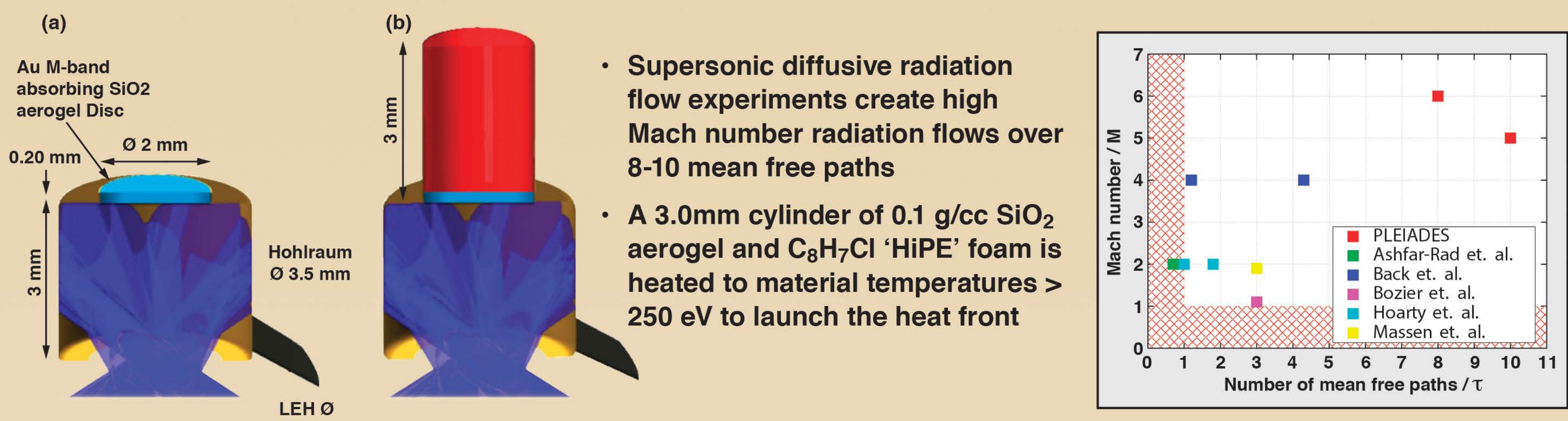
Cooper et al. - "Streaked radiography of an irradiated foam sample on the National Ignition Facility" *Physics of Plasmas* 20, 033301 (2013)

Moore et al. - "Radiation transport and energetics of laser-driven half-hohlraums at the NIF" - submitted to *Physics of Plasmas*

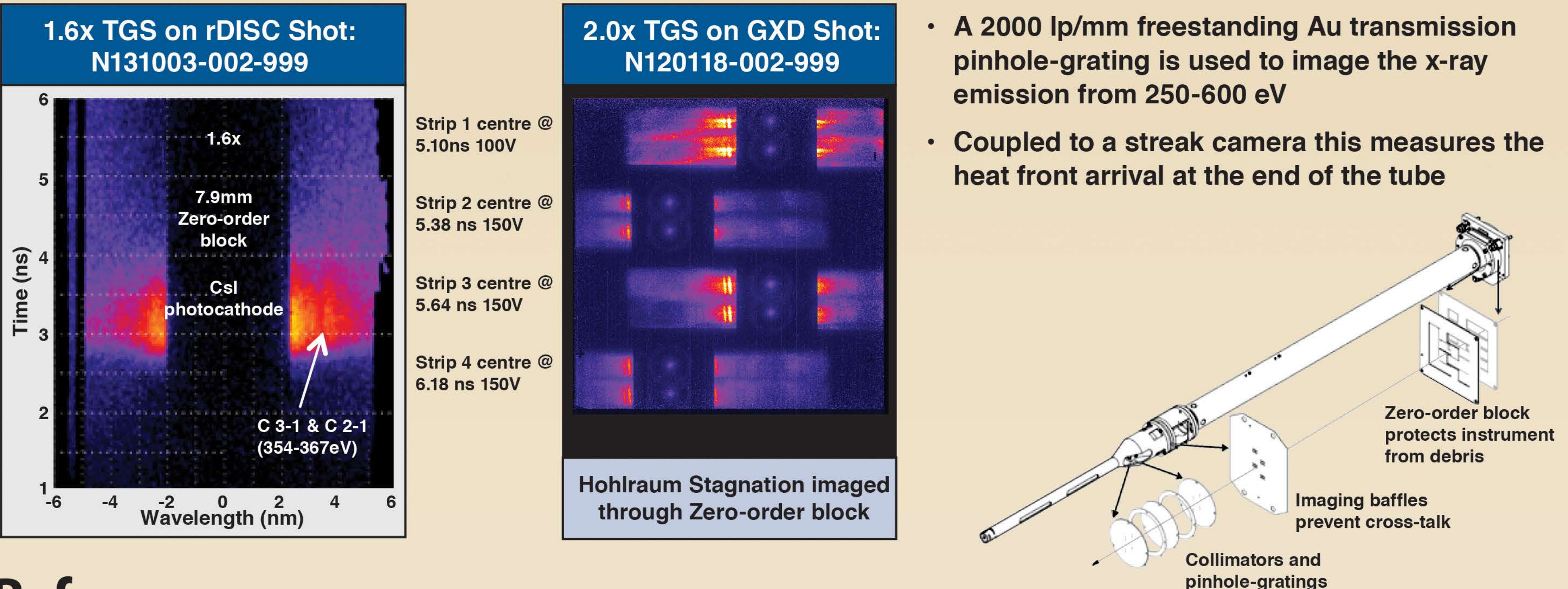
## Supersonic Radiation Flow Platform

### Supersonic Radiation Flow

High temperature (>350 eV) half-hohlraums are used to study supersonic radiation diffusion waves



Arrival of the supersonic heat front is diagnosed using a Transmission Grating Spectrometer coupled to either a streak camera or gated-detector



### References

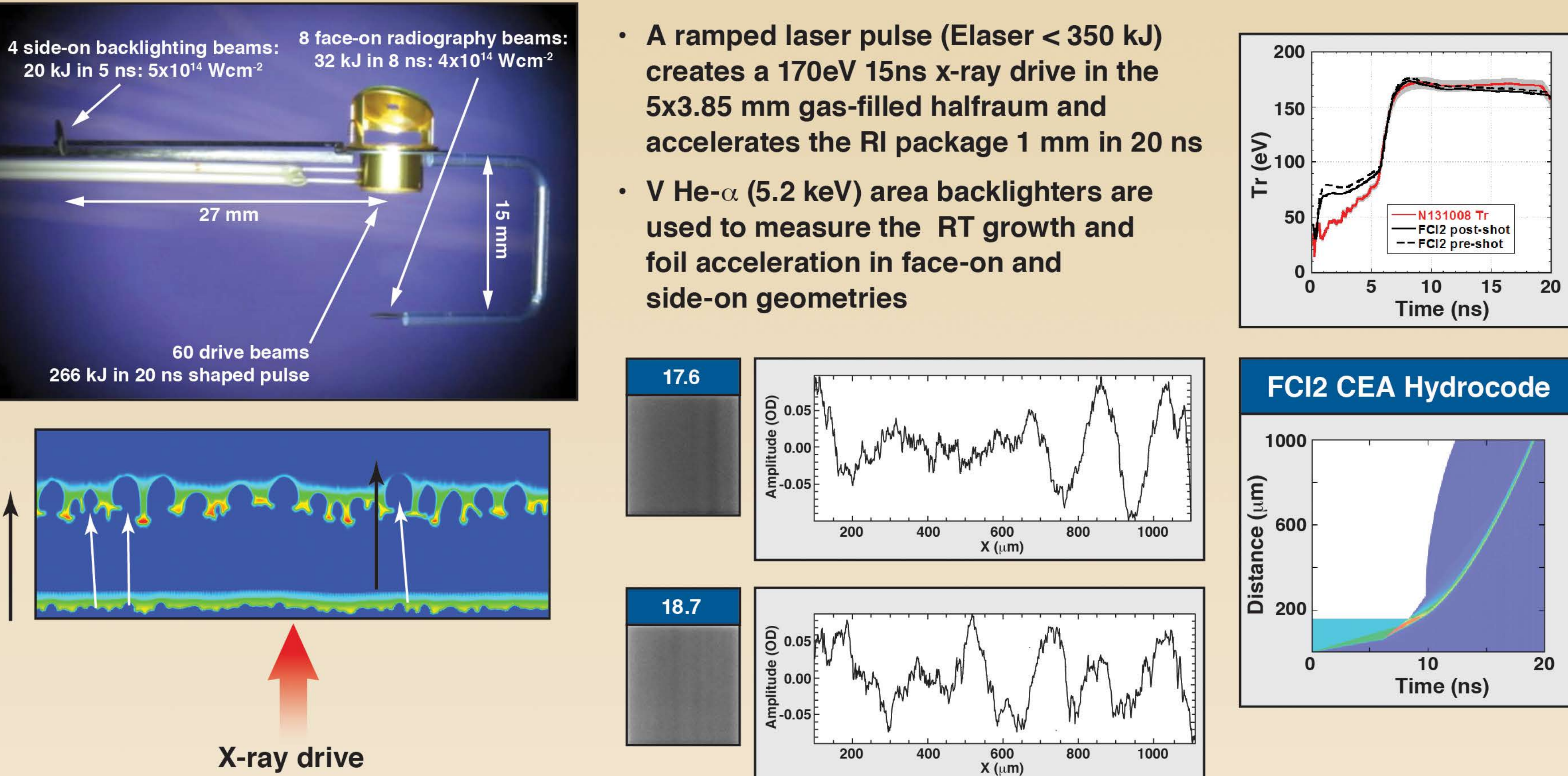
Moore et al. - "Developing High-temperature laser-driven half-hohlraums for high-energy-density physics experiments at the NIF" *Fusion Sci. & Tech.* 68 76 (2012)

Moore et al. - "A soft x-ray transmission grating imaging spectrometer for the National Ignition Facility" *Review of Scientific Instruments* 83 10E132 (2012)

Guymer et al. - "Development and commissioning of a transmission grating spectrometer on the National Ignition Facility" *HEDP* 9 167 (2012)

## Ablative Rayleigh-Taylor Growth Platform

Ablative RT platform indirectly drives a foil into the deeply non-linear RT regime



- A ramped laser pulse (Elaser < 350 kJ) creates a 170eV 15ns x-ray drive in the 5x3.85 mm gas-filled halfraum and accelerates the RI package 1 mm in 20 ns
- V He- $\alpha$  (5.2 keV) area backlighters are used to measure the RT growth and foil acceleration in face-on and side-on geometries

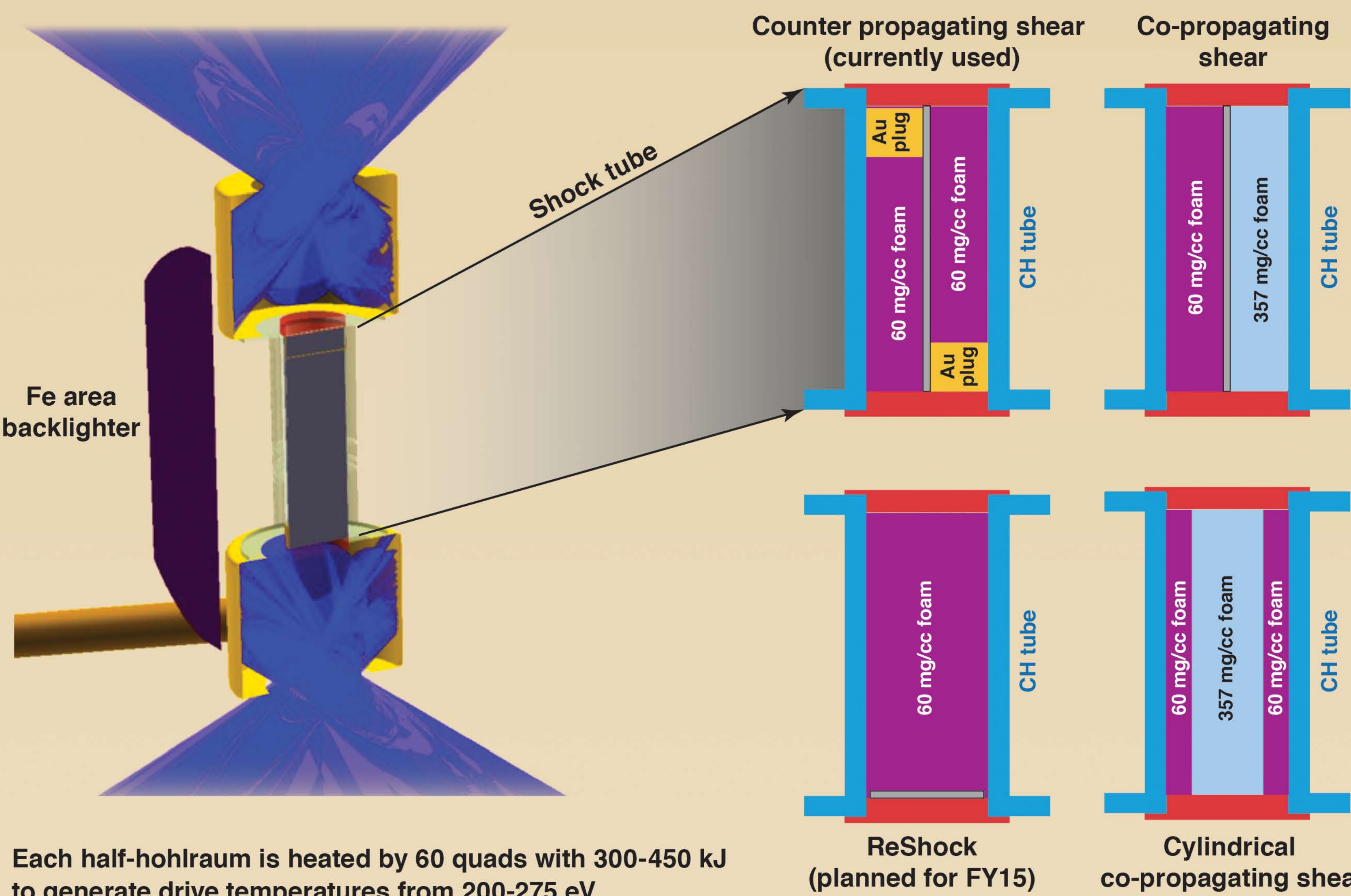
Casner et al. - "Designs for highly nonlinear ablative Rayleigh-Taylor experiments on the National Ignition Facility" *Physics of Plasmas* 19, 082708 (2012)

## Shock-Shear and Mix Platform

### Shock-Shear Experiments

The Shock-Shear Platform was developed to study turbulent mix in a HED regime

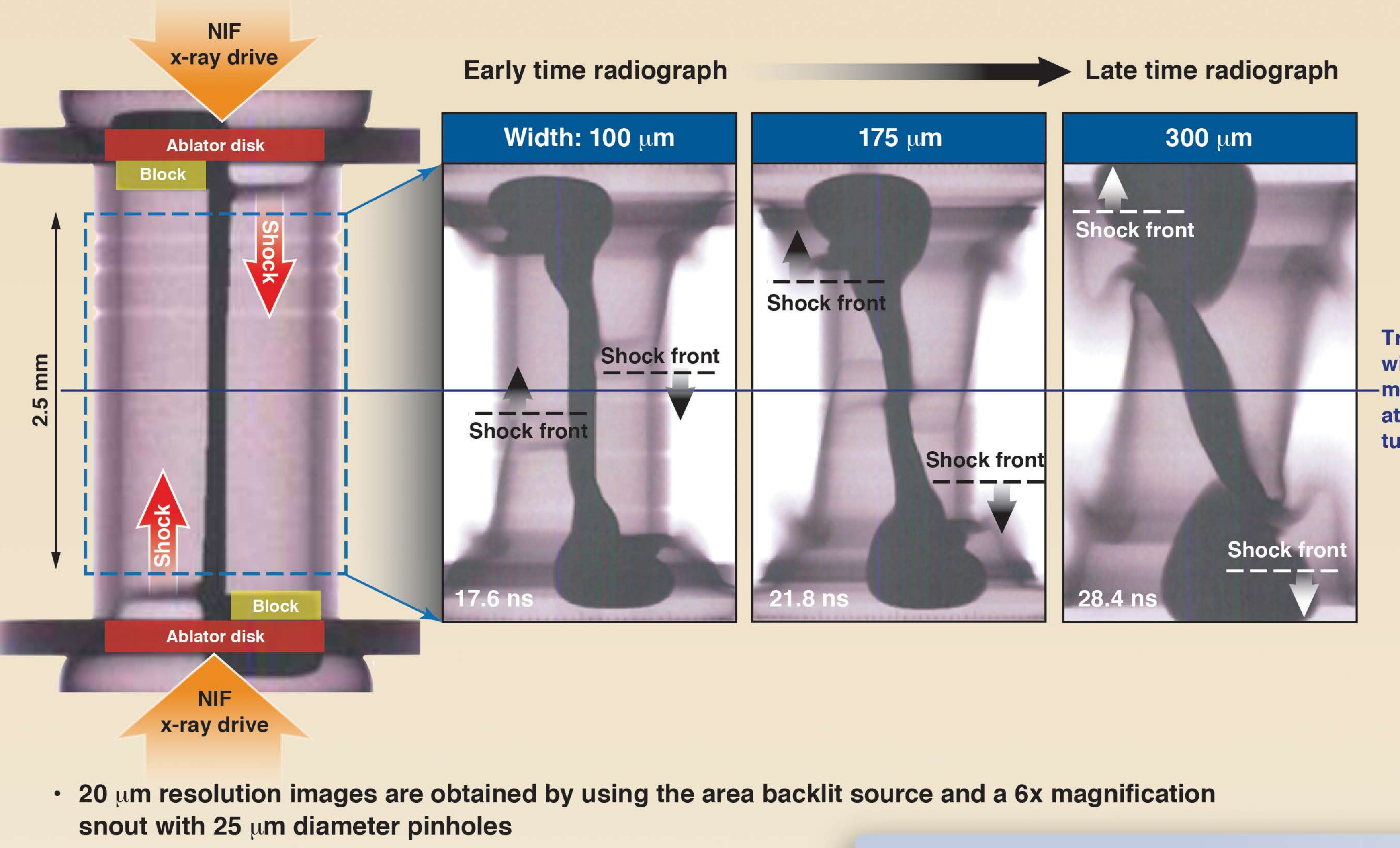
The Shock-Shear is a versatile platform that allows the internal geometry to be changed to study different shock phenomena. Below are examples of the internal geometries designed:



- Each half-hohlraum is heated by 60 quads with 300-450 kJ to generate drive temperatures from 200-275 eV
- This generates shocks between Mach 1.5 and 2.5, and Mbar pressures in the foam and tracer. Shear rates are approximately 3/ns
- An Fe He- $\alpha$  (6.7 keV) area backlighter is illuminated by 6 quads at an average intensity of  $8 \times 10^{14}$  Wcm<sup>-2</sup>

Turbulent mix data can be obtained using the shear tube geometry

- Counter-propagating shocks are launched across a 40  $\mu$ m Al tracer layer with velocity ~115 km/s
- A calculated time-history showing the evolution of the tracer layer from a preheat thickness of about 100  $\mu$ m to a turbulent driven mix width of 300  $\mu$ m is shown



- 20  $\mu$ m resolution images are obtained by using the area backlit source and a 6x magnification snout with 25  $\mu$ m diameter pinholes

For more information visit  
[lasers.llnl.gov/news/publications](http://lasers.llnl.gov/news/publications)

F. W. Doss et al. "Instability, mixing and transition to turbulence in a laser-driven counterflowing shear experiment" *Physics of Plasmas* 20, 012707 (2013)

B. M. Haines et al. "Simulation ensemble for a laser-driven shear experiment" *Physics of Plasmas* 20, 082301 (2013)